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PROGRAM OF RESEARCH ON THE
MANAGEMENT OF RESEARCH AND DEVELOPMENT

Department of Industrial Engineering and Management Sciences

The Technological Institute

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Evanston, Illinois

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Engineering and Management Sciences

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SUMMARY

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This report is divided into 4 sections, corresponding to the format of the original proposal, and using the same numbers for the individual projects in our program. Project No. 3 is not supported by the NASA Grant and project No. 1 is mainly supported by the National Science Foundation (in addition to NASA). They are both included to give a full picture of our research program and to provide a means for NASA personnel to request papers and publications on any of our projects that may be of interest.

Descriptions of Individual Projects and Progress to date (January, 1964)

1. IDEA FLOW IN RESEARCH AND DEVELOPMENT

This study is aimed at increasing our understanding of the complex organizational processes which influence the generation, communication, and disposition of ideas for new technical work in an R and D laboratory.

Progress: A theoretical framework is being developed that is yielding testable propositions about: the communication patterns involved in idea flow; the criteria used for evaluating ideas by people of different functions and backgrounds; organizational response to ideas for new R and D work; and the effects of various factors on project selection. Field studies of idea flow and project selection are being conducted in eight R and D laboratories. Two additional organizations are currently being considered for participation.

Two M.S. Theses have been completed since July 1, one is in progress. A number of articles have been published and several working papers prepared, essentially for internal use.* Three Ph.D. dissertations are in progress.

*A list of articles, theses, and working papers is given in the next section for each individual project.

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2. ORGANIZATION OF RESEARCH AND DEVELOPMENT IN DECENTRALIZED COMPANIES

This is a long-term study of the characteristics and behavior of decentralized companies as they affect the inputs to, capabilities of, and output from R and D.

Progress: This study is now in its final year (it started in 1956). Historical statistics on the trends toward decentralization of large industrial corporations since 1945 have been collected. The organization of R and D in such firms has been traced through this period for over 100 large decentralized companies. Interviews with executives in 35 of these companies have been carried out over the period of the study and a final round of interviewing is currently under way. Two M.S. theses have been completed and two Ph.D. dissertations are in progress. Half a dozen articles and research reports have been completed (see next section), and a book summarizing the project is in preparation.

3. ORGANIZATION OF APPLIED RESEARCH IN DEVELOPING COUNTRIES

The objective of the overall study is to describe the means used by such countries to establish and maintain an R and D capability. A number of alternative strategies that have been used or proposed for this purpose are being analyzed in relation to the stated objectives for R and D in a number of these countries.

Progress: Two M.S. theses have been completed -- one on the Latin American Countries and one on 14 South and Southeast Asia countries. A third study is being initiated on the countries in Sub-Sahara Africa. One paper is in press outlining the entire project. Another is in preparation, defining and illustrating the ideas of "Strategy" and "Pattern" for establishing and maintaining an R and D capability. A third M.S. thesis is in progress.

4. R AND D RESPONSES TO MARKET CRISES

Here we are interested in the reactions of the firm, in terms of R and D behavior, to changes in the market place, technology, the economy, and other environmental conditions. A small sample of firms in several relatively clearly defined markets is being studied.

Progress: Two separate studies are under way on this project. The first is a Ph.D. dissertation, covering two consumer product markets, over the period 1952-1962. The second is in the initial stages of defining a very specific, highly competitive market where the technical objectives and effectiveness criteria are very clear. The various R and D strategies pursued by more than a dozen firms in this new field over the past dozen years are being compared. Due to the highly sensitive nature of the data, no reports containing data on this project will be available for some time, and then only in anonymous form. One working paper is available for limited distribution, outlining the study design and underlying theoretical framework.

5. SOURCES OF R AND D ACHIEVEMENTS IN ELECTRONICS SINCE 1945

This is a spin-off from a study completed in 1962 on research and development in the Chicago-area electronics industry. The data consist of several hundred research achievements in the various fields of electronics, the engineering and commercial applications that resulted from them, and the names of the organizations to whom these achievements are attributed.

Progress: Preliminary screening and categorizing have been completed on the list of achievements. Currently, the list is being submitted to a panel of specialists in the various branches of electronics for ranking of the achievements according to significance. A technical report and journal article are contemplated to complete this project.

6. A DIRECTORY OF RESEARCH-ON-RESEARCH

This is a directory of current and recent studies of the research and development process. It will contain names of researchers, descriptions of projects and several forms of indexing.

Progress: The final stages of data collection are under way and the first edition of the directory is planned for early spring.

7. COSTS OF NEW TECHNICAL SKILL DEVELOPMENT IN RESEARCH AND DEVELOPMENT

This is an attempt to learn how much it costs and how long it takes for R and D organizations to build capabilities in fields that are completely new to them. It traces the development of this capability from the time that a need for it is recognized until the group representing this skill has produced its first effective output.

Progress: Two pilot studies have been carried out so far, yielding preliminary data on a number of specific skills in more than a dozen organizations. A revised interview and questionnaire form are being prepared, one technical report is being written, and an M.S. thesis is being contemplated. Two specific skills -- Lasers and Human Factors have been selected for study in depth.

8. LIFE HISTORIES OF OPERATIONS RESEARCH - MANAGEMENT SCIENCE GROUPS

This study is attempting to describe and then, hopefully, to predict the transition of operations research and other management research groups through the various phases in their life cycle which we have identified. The effects of many internal and external factors are being tested in a series of studies, employing concepts from social psychology and bureaucratic theory.

Progress: One M.S. thesis has been completed and a second is under way. One paper has been published and a technical report presented at a professional society meeting. Currently a theoretical framework and a set of testable propositions is being developed, for the guidance of additional field studies. A file on the movement patterns of professional operations research people is being kept up to date. This study is confined to "captive" OR/MS groups which are integral parts of industrial organizations.

9. ANALYSIS OF RATES OF EXPENDITURE ON DEVELOPMENT PROJECTS

A cooperative study of a number of industrial firms, government agencies, and universities which are pooling (in anonymous form) the data on rates of effort expenditure on selected projects. The attempt is to discover regularities of expenditure patterns and provide a basis of planning and prediction. The data reduction and analysis has been done at Northwestern.

Progress: Following a pilot study in 1960-62, the study design and questionnaire are being reformulated.

13. RESEARCHERS' NEEDS FOR INFORMATION

Analysis of the actual needs of R and D people for technical information. Consideration of the timing and form of information required and the adequacy of present information systems to meet these needs.

Progress: Preliminary designs for a major study in this area have been completed. The design involves a "field-experimental" approach, in which actual researchers in one or more scientific specialties will be studied in relation to their actual, day-to-day information requirements. A series of simulations is contemplated ranging from very simple, completely human-linked systems to very complex man-machine systems.

Publications, Reports, and Working Papers

These are listed according to project number. The degree of availability of each item is indicated by the following code:

AP: Available for distribution; supply plentiful
AS: Available for distribution; supply small
F: File copy only; available on two week loan
L: Limited distribution
I: Internal use only

- | | <u>Availa-
bility</u> |
|---|---------------------------|
| 1. Idea Flow in Research and Development | |
| (1) David E. Hertz and Albert E. Rubenstein, Team Research, Eastern Technical Publications, Cambridge, Mass., 1953. | F |
| (2) 59/2 Albert E. Rubenstein and Robert W. Avery, "Idea Flow in Research and Development," <u>Proceedings of the National Electronics Conference</u> , 1958. | AP |
| (3) 63/2 Albert E. Rubenstein, "Studies of Project Selection in Industry," <u>Operations Research in Research and Development</u> , ed., Burton V. Dean, John Wiley and Sons, Inc., New York, 1963. | AP |
| (4) 63/1 Albert H. Rubenstein and Richard Hannenberg, "Idea Flow and Project Selection in Several Industrial Research and Development Laboratories," <u>Proceedings of the Conference on Economic and Social Factors in Technological Research and Development</u> , Ohio State University, 1962. In Press. | AP |
| (5) 63/16 Albert E. Rubenstein, "Studies of Idea Flow in Research and Development," Presented at The Institute of Management Science Meeting, New York, November, 1963. | AP |
| (6) 63/25 Frank M. Bolen, "A Technique for the Real Time Measurement of the Flow of Ideas in Industrial Laboratories," A Master's Thesis, Department of Industrial Engineering and Management Sciences, Northwestern University, August, 1963. | F |
| (7) 63/26 Louis C. Goldberg, "Dimensions in the Evaluation of Technical Ideas in an Industrial Research Laboratory," A Master's Thesis, Department of Industrial Engineering and Management Sciences, Northwestern University, August, 1963. | F |
| 2. Organization of Research and Development in Decentralized Companies | |
| (1) 62/1 Albert H. Rubenstein, "Organization and Research and Development Decision-Making Within the Decentralized Firm," <u>The Rate and Direction of Inventive Activity</u> , A Report of the National Bureau of Economic Research, Princeton University Press, 1962. | AS |

- (2) 62/3 Albert H. Rubenstein, "The Constraints of Decentralization," Chemical Engineering Progress, August, 1962. AP
 - (3) 63/3 Albert H. Rubenstein and Michael Radnor, "Top Management's Role in Research Planning in Large Decentralized Companies," Proceedings of International Federation of Operations Research Societies, Oslo, 1963. AS
 - (4) 63/12 Albert H. Rubenstein, "Organizational Factors Affecting Research and Development Decision-Making in Large Decentralized Companies," August, 1963. AS
 - (5) 63/20 Michael Radnor, "Top Management Control and Evaluation Over Semi-Autonomous Operating Divisions," A Research Program, Department of Industrial Engineering and Management Sciences, Northwestern University, January, 1963. F
3. Organization of Applied Research in Developing Countries
- (1) 55/1 Albert H. Rubenstein, "Evaluation of Possibilities of Research Effort in a New Field of Technology," Royal Swedish Academy of Engineering Sciences, December, 1955. AS
 - (2) 63/5 Albert H. Rubenstein and Earl Young, "An analysis of Alternative Strategies for Organizing the Applied Research Activities of Developing Countries," Proceedings of the Symposium on the Possibilities of Operations Research in Developing Countries, Paris, June, 1963. AS
 - (3) 63/15 Mario D. Pantin, "A Study of the Role of Scientific Research in the Growth and Development of the Latin American Countries," A Master's Thesis, Department of Industrial Engineering and Management Sciences, Northwestern University, October, 1963. F
 - (4) 63/27 Pakorn Adulbhan, "A Study of the Role of Scientific Research 'R and D' in the Industrial Development of Selected South and Southeast Asia Countries," A Master's Thesis, Department of Industrial Engineering and Management Sciences, Northwestern University, December, 1963. F
5. Sources of Research and Development Achievements in Electronics Since 1945
- (1) 58/1 Albert H. Rubenstein, "Problems in Financing and Managing New Research-Based Enterprises in New England," A Study Conducted for the Federal Reserve Bank of Boston, Second Printing, April, 1959. F
 - (2) 59/3 Albert H. Rubenstein, "The Electronics Industry in New England to 1970," A Study Conducted for the Federal Reserve Bank of Boston, December, 1959. F
 - (3) 62/5 Albert H. Rubenstein and Dawson E. Brewer, Research and Development in the Chicago Area Electronics Industry, Northwestern University, 1962. AP

7. Costs of New Technical Skill Development in Research and Development

- (1) 63/21 Robert B. Martin, "New Technical Skill Development," A Summary of Seminar Discussions, Department of Industrial Engineering and Management Sciences, Northwestern University, December, 1963.

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8. Life Histories of Operations Research - Management Science Groups

- (1) 60/1 Albert H. Rubenstein, "Integration of Operations Research Into the Firm," Journal of Industrial Engineering, September-October 1960, vol. XV, no. 5, p. 421. AS
- (2) 61/2 Albert H. Rubenstein and John B. McColly, "Phases in the Life Cycle of Industrial Operations Research Groups," Presented at the Joint TIMS - ORSA Meeting, San Francisco, November, 1960. AS
- (3) 63/8 Norman R. Baker, "Descriptive Model of Several Environmental Factors Affecting Industrial Operations Research-Management Science Activities," A Master's Thesis, Department of Industrial Engineering and Management Sciences, Northwestern University, August, 1963. AP
- (4) 63/17 David Heiman, "List of Variables in the Birth and Death of Operations Research Groups," A Summary of Seminar Discussions, Department of Industrial Engineering and Management Sciences, Northwestern University, November, 1963. I

9. Analysis of Rates of Expenditure on Development Projects

- (1) 60/4 Albert H. Rubenstein, "Data from SCARDE Pilot Study," May, 1960. F

13. Researchers' Needs for Information

- (1) 62/2 Albert H. Rubenstein, "Timing and Form of Researchers Needs for Technical Information," Journal of Chemical Documentation, 1962, No. 2, p. 28. AP

Personnel Engaged in Program Since July 1, 1963

Name	Position	Project Number												
		1	2	3	4	5 ^(a)	6	7	8	9 ^(b)	10	11	12	13
Albert H. Rubenstein	Professor of Industrial Engineering and Management Sciences **	X	X	X	X	X	X	X	X	X	X	X		
Jack Siegman	Research Sociologist ^{OP}	X												
Gustave Rath	Associate Professor of Industrial Engineering and Management Sciences **			X				X				X		
Robert W. Avery	Assistant Professor of Sociology, University of Pittsburgh ^{OP}	X	X											
Frank Baker	Assistant Professor of Psychology, Lehigh University ^{OP}	X												
Bakorn Adulbhan	Research Fellow ^O			X										
Norman R. Baker	Research Assistant and Research Fellow ^{*O}	X												
William Batchelor	Research Assistant ⁺		X											
Frank Bolen	Associated Graduate Student ^{*O}	X												
Jack Doyle	Research Assistant ^{*O}	X												
Louis C. Goldberg	Research Assistant ^{*O}	X												
Richard C. Hannenberg	Research Assistant ^O	X			X									
David Heiman	Research Assistant ⁺								X					
Takeshi Kawase	Research Assistant [*]							X						
Ronald M. Kirshbaum	Research Assistant		X											
Robert Martin	Research Assistant ⁺							X						
John B. McColly	Associated Graduate Student ^O				X									
Edward C. Murphy	Research Assistant [*]		X											
Mario D. Pantin	Research Assistant [*]		X	X										
William H. Pound	Research Assistant and Research Fellow ^{*O}	X												

* Summer only

Summer and Occasional Consultation

+ 1963-64 Academic Year Only

O Not paid out of NASA funds

** Paid for a Portion of the Summer only out of NASA funds

(a) In cooperation with the NASA Social Science Project, Univ. of Calif. at Berkeley

(b) In cooperation with the Harvard Graduate School of Business

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		1	2	3	4	5(a)	6	7	8	9(b)	10	11
Michael Radnor	Research Fellow ⁰		X									
James Utterback	Research Assistant ¹⁰	X										
Earl Young	Research Assistant ¹⁰			X								

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